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STUDY ON THE COMPARATIVE VIABILITY OF DIPLOID AND HAPLOID LARVAL DRONE HONEYBEES*

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SUMMARY

Eggs laid by 3 selected inbred queens producing brood of low survival rate were hatched in an incubator. Diploid larvae from worker cells and haploid larvae from drone cells were reared further under identical conditions in an incubator; 60% of 89 haploid larvae and 63% of 128 diploids reached the age of 5 days. About half the diploids were drones. Of the diploid drone larvae that reached 5 days, 43% lived to 9 days, compared with 36% of the haploids. The average weight of drone larvae at transference to pupation dishes was 357·7 mg. for diploids and 296·9 mg. for haploids. (The difference was not statistically significant, but might well be so with a greater number of larvae.) The viability of diploid drone larvae is certainly not lower, and may possibly be higher, than that of the haploids: by using right techniques for rearing, it should be possible to rear larger numbers of diploid drones to the imago.

INTRODUCTION

It has been shown that drone larvae can develop from fertilized eggs (Woyke, 1963*a*). Results described in a more recent paper (1965), together with those not yet published, enable us to refer to them as diploid drones. In the hive the larvae are eaten by the workers shortly after hatching from the egg (1962, 1963*b*), but the drones can be reared to the imago in a laboratory, in isolation from bees (1963*d*, *e*).

The papers above show that the viability of diploid drone larvae is the same as that of female larvae up to an age of 5 days. Further comparison of viability was impossible: the females had to be transferred earlier to pupation dishes, whereas the diploid drone larvae were still being transferred on to new food every day. They were transferred to pupation after 9 or 10 days of rearing in the incubator. Although many females were reared to the imago, only three diploid drones reached this stage.

The question arose whether the viability of diploid drones is lower in later developmental stages, or whether the technical difficulties in rearing drones to the imago were common to both diploid and haploid. This problem was examined by rearing diploid drones together with a control group of normal viable haploid drones.

MATERIAL AND METHODS

Three inbred queens producing brood of low survival rate were chosen. Eggs laid by these queens in worker and drone cells were hatched in an incubator (Woyke, 1963*d*, *e*). It was assumed that half the larvae hatched in worker cells would be diploid drones; the drone larvae hatched in drone cells served as a control group. Altogether 217 larvae were grafted on to royal jelly in queen cells in an incubator. Out of them 128 were taken from worker cells and 89 from drone cells. The larvae were reared, as previously described

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(1963*d*, *e*), in six different series. In some series the number of control larvae was about the same as that of diploid larvae (females + males). In others only half as many haploid as diploid larvae were reared, and it was assumed that the number of haploid and diploid larvae would be the same after separating the two diploid sexes.

The haploid drone larvae in the control group originated in some series from the same queen as the diploid ones, in other series from different queens. Haploid and diploid larvae of each series were kept in separate dishes, but they were fed on the same food, and were kept in one desiccator under the same conditions. Series 6 and 10 were divided into subseries consisting of haploid and diploid larvae. Larvae of the different subseries were reared at different relative humidities, ranging from 100% to 96%. The number of live larvae was recorded each day.

The sex of diploid larvae was determined at 5 days old by the method described earlier (Woyke, 1963*c*). After this the viabilities of only diploid and haploid drone larvae were compared. The drone larvae were transferred to pupation after 9 days of rearing. Larvae of four series were weighed just before transferring them to pupation dishes; larvae of the two last series were not, because they were reared during the final days in glass tubes and could not be weighed without food.

RESULTS

Survival of young haploid and diploid larvae (females and males)

The numbers of larvae surviving to different stages are presented in Table 1. In every series the number of live diploid and haploid larvae decreased gradually as rearing proceeded. There was a difference in the percentage of diploid and haploid larvae still alive after 5 days, which ranged (in different series) from 8 to 26%. The difference was higher in the less numerous series, but the most important fact is that neither haploid nor diploid showed a consistently lower survival rate than the other. The average survival rate for all series was 63% for diploid larvae and 60% for haploid drone larvae. The viability of the 'low-survival' brood (females and diploid drones) is thus similar to the viability of normal haploid drone larvae up to the age of five days. It has already been shown that during this period the viability of diploid drone larvae is similar to that of the female larvae (Woyke, 1963*d*, *e*). (In the present investigation, 44 of the 81 diploids surviving to 5 days were drones and 37 females.)

It can thus be concluded that up to the age of 5 days the viability of diploid and haploid drone larvae is similar.

Survival of older haploid and diploid drone larvae

After five days of rearing, the sex of diploid larvae could be determined. In every series about half the diploid larvae were males (Table 1). The diploid drones could now be separated from the females, and a direct comparison made between diploid and haploid drones. The number of live larvae of both kinds decreased gradually from the 5th to 9th day, and by the time for transference to pupation, few survived in any series. The final percentage survival therefore showed great variation, and the total results are more informative. Of the drone larvae that had survived to 5 days, 43% diploid and 36% haploid larvae reached the age of 9 days — a few more diploid than haploid. The survival rate

TABLE 1. Comparison of the viability of diploid (D) and haploid (H) larvae in subsequent days of rearing in an incubator

Queen and series no.		*Type of larvae*	*No. diploid (both sexes) and haploid drone larvae still alive on various days*						*% living to 5 days*	*No. diploid and haploid drone larvae still alive on various days*					*% of larvae reaching 5 days that lived to 9 days*
			0	1	2	3	4	5		5	6	7	8	9	
752	6a	D	47	47	41	33	33	29	62%	16	16	11	4	4	25%
752	6b	H	35	35	28	28	27	23	70%	23	22	15	11	10	44%
748	7a	D	30	28	25	25	25	23	72%	12	11	11	9	7	58%
748	7b	H	15	14	14	14	14	13	87%	13	9	4	3	3	23%
753	8a	D	8	8	8	6	6	6	75%	3	3	1	1	1	33%
753	8b	H	4	4	3	2	2	2	50%	2	2	2	2	2	100%
753	10a	D	19	19	17	16	13	13	68%	6	6	6	4	4	67%
753	10b	H	19	18	16	13	8	8	42%	8	8	4	4	3	38%
753	12a	D	16	16	15	10	10	4	25%	2	2	2	1	1	50%
748	12b	H	8	8	8	5	2	0	0%	0	0	0	0	0	0%
753	14a	D	8	8	6	6	6	6	75%	5	5	5	4	2	40%
748	14b	H	8	8	7	7	7	7	88%	7	7	7	2	1	11%
total no.		D	128	126	112	96	93	81	63%	44	43	36	23	19	43%
		H	89	87	76	69	60	53	60%	53	48	32	22	19	36%
% still alive		D	100%	98%	88%	75%	73%	63%		100%	98%	82%	52%	43%	
		H	100%	98%	85%	78%	67%	60%		100%	91%	60%	42%	36%	
% daily mortality		D	—	2%	11%	14%	3%	13%		—	2%	16%	36%	17%	
		H	—	2%	13%	9%	13%	12%		—	9%	33%	31%	14%	

of diploid drone larvae at this time was certainly not lower than that of the haploids.

Table 1 shows that the mortality rate was highest for both types of drone larvae during the last few days. During this time the females ceased feeding and were already in the pupation dishes. This may partly explain why the final results of rearing females and males differ so much, although the viability was much the same up to 5 days.

Weight of haploid and diploid drone larvae

The average weight reached by both types of drone larvae being transferred to pupation dishes is shown in Table 2. Fewer larvae are represented here than in Table 1, because those not ready to spin their cocoons (due to unsatisfactory development—1 haploid and 2 diploids) and those transferred to glass tubes during the feeding period are excluded.

TABLE 2. Weight of diploid and haploid drone larvae when transferred to pupation dishes

	Series no.	6	7	8	10	*Total or average*
diploid drones	No. larvae	4	7	1	2	14
	Mean weight (mg.) ..	271·0	421·3	405·0	285·0	357·7 ± 25·4
haploid drones	Mean weight (mg.) ..	284·9	358·5	282·0	305·3	296·9 ± 17·1
	No. larvae	10	2	2	3	17

The average weight of all 14 diploid drone larvae was 357·7 mg. and that of 17 haploid ones 296·9 mg. At the time of transference to pupation the diploid larvae were thus 20% heavier than the haploid ones. But with these small numbers of larvae, the smallest difference that would be statistically significant ($t=0\cdot05$) is 62·5 mg., slightly higher than the experimental difference of 60·8 mg. Thus although there is a high probability that diploid drone larvae are heavier than haploid, we cannot state for certain whether this is so, until more diploid drone larvae can be reared. We can, however, state that diploid drone larvae do not develop less well than haploid ones.

History of the brood after the end of the feeding period

The drone larvae started to spin cocoons after being transferred to pupation dishes. Some died before reaching the prepupal stage, and many of the prepupae did not pupate. No perfect imago of any type of drone was reared.

Many of the female larvae that were reared with the diploid drone larvae for the first 5 days pupated, and imagines of queens or workers were reared. We can therefore state that laboratory rearing of males (haploid or diploid) is more difficult than rearing females. The longer development period of drones may be one of the factors hindering their successful rearing outside the colony.

CONCLUSION

All results obtained demonstrate that the viability of diploid drone larvae is similar to that of haploid drone larvae; it may possibly be slightly higher.

The difficulty in rearing a large number of diploid imaginal drones is not their lower viability, but insufficient knowledge as to the conditions necessary for development of drones in general. It should be possible to rear diploid drones to the imago stage if the correct techniques could be developed.

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